FARM Rain Erosion/Impact Measurement Laboratory

The RF Sensors Branch of the Naval Air Warfare Center Aircraft Division conduct rain erosion/impact measurements at it's Facilities for Antenna and RCS Measurements (FARM). Radome material sample of one inch size is mounted at the end of a 48 inch aerodynamic steel counterbalanced rotating arm in the FARM's Rain Erosion/Impact Measurement Laboratory. The arm is housed in a 10 foot diameter steel chamber and rotated through a controlled density (0.5 - 1.0 inch per hour) and droplet size (2.0 - 2.5 mm) rain field environment at velocities from 300 N MPH to Mach 1.8.

The FARM Rain Erosion/Impact Measurement Laboratory

The primary goal of the Rain Erosion/Impact Measurement Laboratory has been to produce results of far greater reproducibility than any other rotating arm test apparatus, and to recognize the various failure mechanisms. This endeavor was achieved through a machine design which emphasized consideration of drop delivery, rainfall intensity, chamber pressure, temperature, and air turbulence reduction within the chamber walls.

The rain erosion/impact chamber consists of an aerodynamic steel counter-balanced arm which rotates within a ten foot diameter steel chamber. A Titanium test sample holder on the end of the arm contains a 1.000 inch (+0.000/-0.002 inch) diameter test specimen, with a maximum thickness of approximately 0.80 inch. The sample is exposed to a rain field of controlled drop size and rate. The rotating arm is directly coupled to a vertical steel shaft inside a gusseted shaft housing. The housing is an integral part of the lower chamber weld assembly. Included in the assembly are the legs that support the chamber, auxiliary pumps, reservoirs, and control boxes. A right angle gear system is coupled at the bottom end of the shaft to supply 2.0:1 ratio from the power supply to the vertical shaft. To eliminate the transmission of torsional vibrations into the gear box and shaft assembly, a torque converter is used to transfer power from the 534 cubic inch. Ford industrial engine to the horizontal drive shaft. The chamber can be sealed and evacuated to simulate altitude and reduce drag. The atmosphere temperature is controlled by cooling fins in the upper and lower portions of the chamber. Installed in the top section of chamber is the rain field system, which supplies water to 30 needles from three copper manifolds fed by a six foot vertical pipe representing a head pressure system that can be adjusted to maintain various pressures. All the needles are restricted to a one inch circumferential band that is located 10.5 inches above the sample path to allow the drops to accelerate to a required velocity. The needles and accelerating drops are protected by shroud tubes to reduce drop deflection from the induced shock waves and turbulence caused by rain impacting the sample and the vortex created by the rotating arm.

The rain field is calibrated for each test. Rain rates of 0.3, 0.5, and 1.0 inch/hour are achievable. The rain drop size are 2.0 or 2.5 mm. The rain impingement assessment can be performed with a high degree of reproducibility at velocities from 300 mph up to mach 1.8. For the purpose of uniformity in engineering evaluation of various radome materials, the majority of rain erosion tests are conducted initially at mach 0.67 (500 mph). Typically, samples are exposed to one inch per hour rainfall at normal incidence (90 impact). Sample holders for 32 and 45 impact angles are available. The duration of rain impacting that a sample can withstand prior to structural failure, or penetration through protective coatings is indicative of material performance. Therefore, all other parameters, except time, impact angle and mass are held constant. Sample duration's greater than five minutes can be employed in randoms accompanied by a routine examination schedule. For radomes produced from material with rain impact duration's greater than five minutes, repair-replacement schedules can be prepared for aircraft maintenance personnel. The Rain Erosion/ Impact Measurement Laboratory rain impingement assessment can be performed with a high degree of reproducibility at velocities up to mach 2.0. For the purpose of uniformity in evaluation of various radome materials, the majority of rain erosion tests are conducted initially at mach 0.67 (500 mph). At this threshold velocity, samples are exposed to one half inch per hour rainfall at 90 degree impact angle. The duration of rain impacting that a sample can withstand is indicative of material performance. Therefore, all other parameters, except time and mass can be employed in radomes accompanied by a routine examination schedule.

During the past several years we have conducted rain erosion/impact testing and evaluation of various materials in classes such as thermosets, thermoplastics, composites, laminates and elastomeric coatings. Through the utilization of this lab, we have been able to generate valuable data on mass loss of solid laminates and thermoplastics as a function of rain impact exposure.

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